PROC. BIOL. SOC. WASH.
106(2), 1993, pp. 390–401

UPPER TRIASSIC REPTILE FOOTPRINTS AND A COELACANTH FISH SCALE FROM THE CULPEPER BASIN, VIRGINIA

Robert E. Weems and Peter G. Kimmel

Abstract.—Three ichnotaxa (*Chirotherium, Brachychirotherium,* and *Plesiornis*) are reported for the first time from the Culpeper basin. They occur near the base of the Manassas Sandstone and represent the oldest vertebrate faunal assemblage from the basin. A fish scale from the overlying Balls Bluff Siltstone, referable to *Diplurus,* is the first report of a coelacanth from Triassic strata of the Culpeper basin.

Palynological studies have established that strata in the Culpeper basin (Fig. 1) range from Late Triassic to Early Jurassic in age (Cornet et al. 1973, Cornet 1977, Litwin et al. 1991). Fish remains are abundant locally in the Jurassic column of the basin (Schaeffer & McDonald 1978) but are rare and usually disarticulated in the Triassic column (Gore 1986). Tetrapod remains are found more rarely. Parasuchian bones and teeth have been reported in the Triassic column from River Road in Montgomery County, Maryland, near Dulles Airport in Fairfax County, Virginia, and from the Culpeper Stone Company quarry, Culpeper County, Virginia (Weems 1979, Weems & Wiggs 1991, Weems 1992). Triassic dinosaur footprints are documented from the Culpeper Stone Company quarry, Virginia (Weems 1987, 1992), and Jurassic dinosaur footprints have been reported from the region near Aldie, Loudoun County, Virginia (Gilmore 1924, Roberts 1928, Pannel 1985). This paper documents a fifth tetrapod locality in the Culpeper basin and the first evidence of a Triassic coelacanth fish.

Locality Data

The new footprint occurrences are from a locality found by Peter Kimmel in July of 1983 in the Manassas 7.5′-quadrangle along Compton Road east of Virginia Route 28 in Fairfax County (Fig. 2). Located about 365 m west of the eastern margin of the Culpeper basin, this site was excavated to construct a brick pumping station. Among numerous stone slabs which were unearthed, five contained lightly impressed footprints. Four represent matching part and counterpart prints, the fifth is an unmatched counterpart print.

The locality is in the lower Poolesville Member of the Manassas Sandstone at a horizon less than 50 m above the base of the exposed sequence in the Culpeper basin. This is the lowest (oldest) horizon in the basin that has yielded vertebrate remains. Although some workers have assumed the Poolesville to be Carnian in age, a definitive palynoflora indicates that at least the upper part of this unit is early Norian (Litwin et al. 1991). The lower Poolesville Member remains undated palynologically, but it is considered here to be early Norian until positive evidence is found for any Carnian strata in the basin.

An impression of a large coelacanth scale was found by Juergen Reinhardt and Wayne Siglio (U.S. Geological Survey) near the site that yielded bones of *Rutiodon* cf. *R. manhattanensis* (Weems 1979). The fish scale locality lies immediately east of Dulles International Airport in Loudoun County, Virginia, near the eastern county border (Fig. 3). This single scale, the first record of a

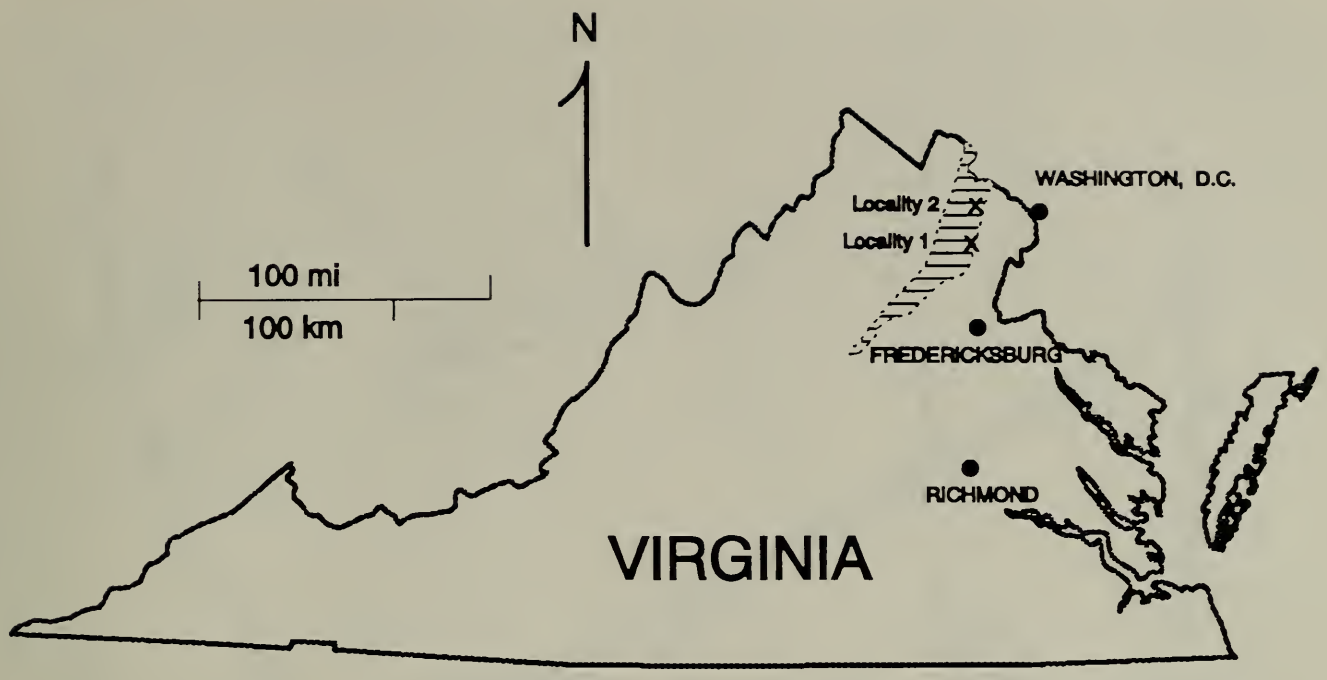

Fig. 1. Map of Virginia showing area underlain by early Mesozoic rocks of the Culpeper basin. Footprint locality (1) and fish scale locality (2) of this report are indicated. Detailed locality data are in Figs. 2 and 3.

sarcopterygian fish in the Triassic column of the Culpeper basin, comes from near the base of the Balls Bluff Siltstone, which is early Norian in age (Lee & Froelich 1989, Litwin et al. 1991).

Footprint Material

One pair of part and counterpart slabs (USNM 412533) contains a lightly impressed pes impression with a large digit located far to the rear and to the side of the track (Fig. 4). The position and large size of this digit readily characterize this print as that of a *Chirotherium.* The relative proportions of this track are almost identical to those of *Chirotherium lulli* Bock, but in absolute size it is twice as large as the type of that species. Because Baird (1954) observed that the type (and only other described specimen) of *C. lulli* was unusually small compared to other species of *Chirotherium,* we presume that our specimen represents an adult of the described Newark species rather than a new and larger species of nearly identical proportions. Therefore we assign our specimen to the described species *Chirotherium lulli.* Footprints assigned to *Chirotherium* probably were made by pseudosuchian rauisuchids (Charig et al. 1976).

A third track-bearing slab (USNM 412534) contains a counterpart impression of a left manus and pes set (Fig. 5). The pes is large and shows the impression of three forwardly directed blunt-tipped toes. The manus is proportionally much smaller than the pes and has three slender digits that are very nearly the same length. The general proportions of these prints are closer to those of *Grallator,* "*Atreipus,*" and *Brachychirotherium* than they are to any other described Triassic ichnogenera. Olsen & Baird (1986) named "*Atreipus*" for *Grallator*-like tracks which also had manus prints. However, a recent review of tridactyl theropod tracks from the Newark Supergroup (Weems 1992) has shown that the pes of each of the three described species of "*Atreipus*" has an exactly analogous pes in three species of *Grallator.* As the manus of *Grallator* is (by definition) unknown, the distinction between "*Atreipus*" and *Grallator*" rests on a non-character (the absence of manus prints in *Grallator*). "*Atreipus*" most likely is a *Grallator* walking on four feet instead of


38° 52' 50" N
77° 27' 30" W
Centreville
(U.S. Route 50)
Centreville Road (Va. Route 28)
Interstate 66
Lee Highway
Big Rocky Run
Little Rocky Run
power line
FOOTPRINT SITE
Compton Road
Bull Run
N
0
0.5
1.0
Kilometers
JURASSIC
TRIASSIC
PRE-MESOZOIC
Diabase
Thermally Metamorphosed Rock
Balls Bluff Siltstone
Poolesville Member
Reston Member
Manassas Sandstone
Schist and Gneiss

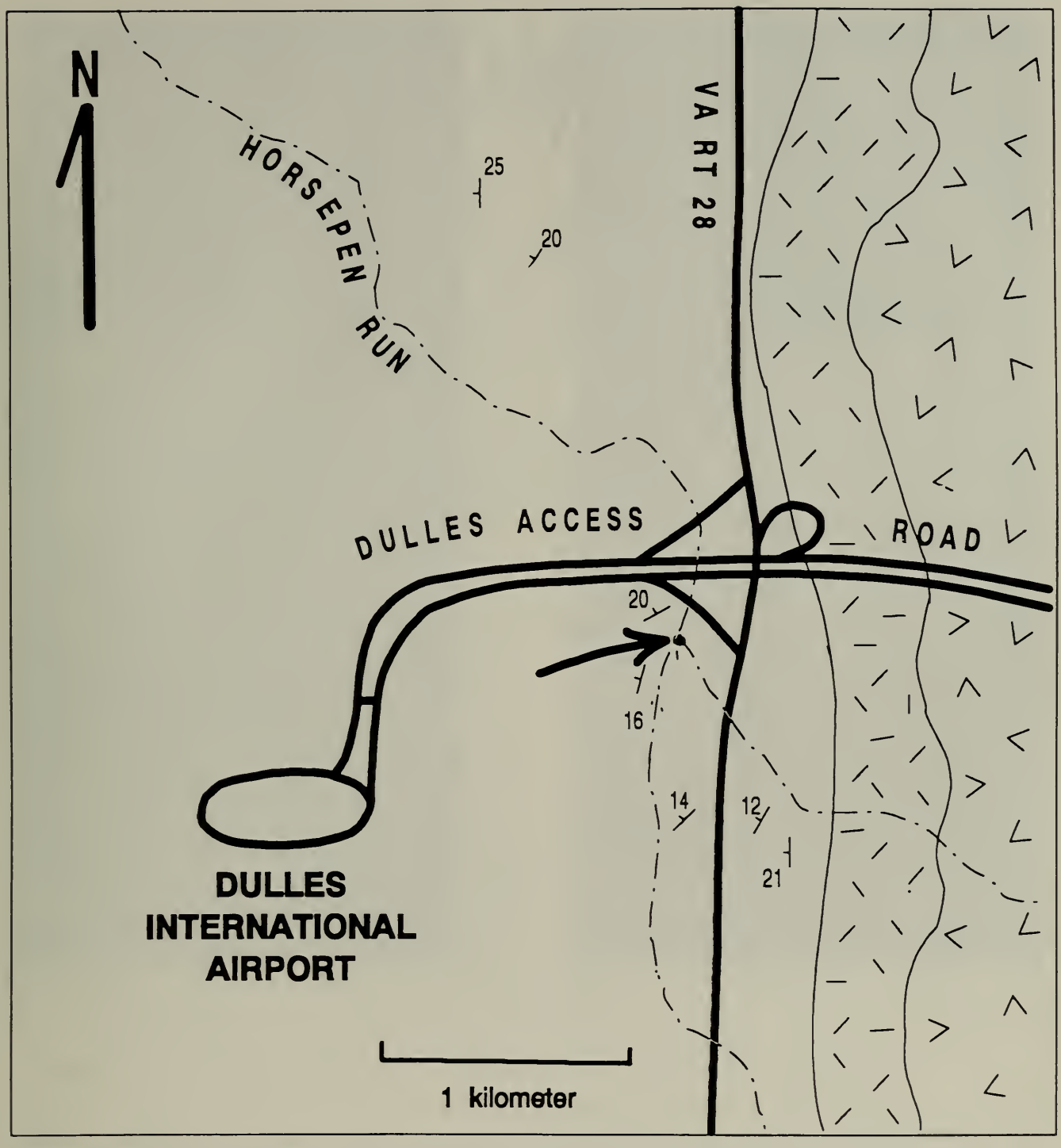

Fig. 3. Map showing location of fish scale locality 2 (Loudoun County). Symbols and patterns are the same as in Fig. 2.

two, so the distinction between these two genera becomes meaningless taxonomically. For this reason, these two genera were synonymized and the earlier name *Grallator* was retained. Thus a choice of placement for the specimen here in question falls between *Grallator* and *Brachychirotherium.*

The absolute size of our print is close to

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Fig. 2. Map showing location of footprint locality 1 (Fairfax County). Geology and border fault located from Lee (1979). Stratigraphic column on left shows relative age and sequence for units shown on map. Jurassic diabase is a sill that baked the immediately surrounding Triassic rocks. "T"-shaped symbols and numbers represent strike and dip of sedimentary rocks.

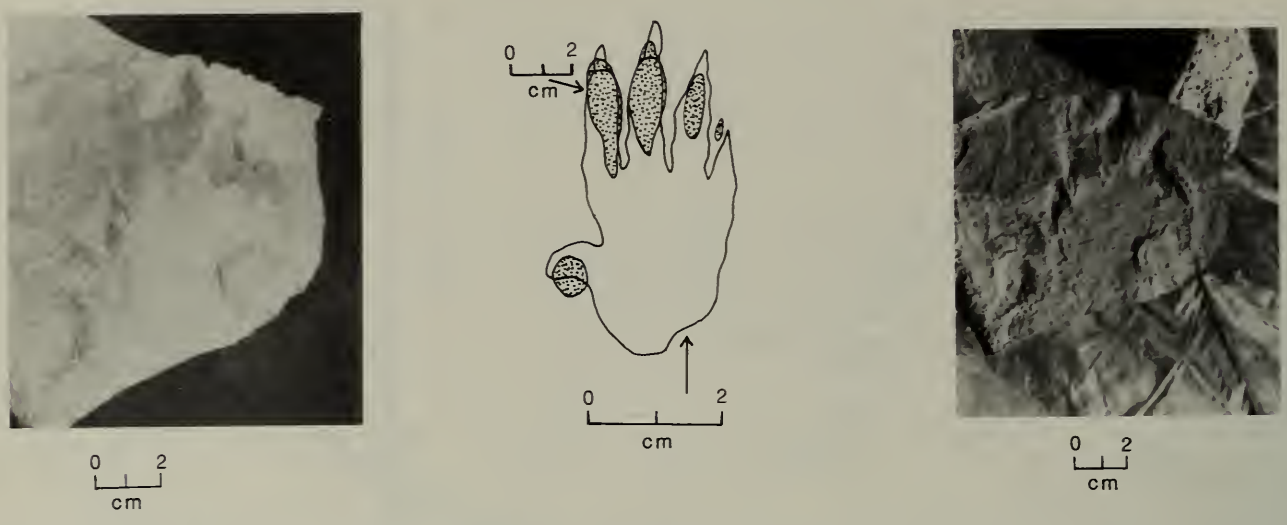

Fig. 4. (middle) Outline drawing of right pes of type specimen of *Chirotherium lulli* (after Baird 1954), mirror-reversed to left pes. Overprinted on this pes outline is the best fit outline of the *Chirotherium* footprint from Culpeper basin (stippled areas). Photographs of the left pes imprint of *Chirotherium lulli* (USNM 412533) from Culpeper basin are shown in strong (right) and subdued (left) light. Other linear features in photographs are mudcrack boundaries.

the size of an adult *Grallator* and much smaller than an adult *Brachychirotherium* (Fig. 6). But placement of the outline of our print on published drawings of a *Grallator* print (Olsen & Baird 1986) and a *Brachychirotherium* print (Baird 1954) shows that the toe proportions, toe shapes, and apparent placement of the animal's weight on the ground are what would be expected from the foot of *Brachychirotherium,* specifically *Brachychirotherium parvum* (C. H. Hitchcock). Possibly because the print is lightly impressed, no impression was left of digit I or of the small nails. The proportions of the toes and the placement of weight represented by our footprint are not so similar to *Grallator.* Moreover, the very large and sharply pointed toes of *Grallator* should have left some evidence of their presence even though the print is lightly impressed. Therefore, we assign this print to *Brachychirotherium.* The small size leaves open the possibility that our specimen represents a new and smaller species of this genus. But our specimen easily could have been made by a juvenile animal, and fossil footprints can display considerable variability (Weems 1992). Thus for now we are content to assign this specimen to *Brachychirotherium parvum.* Haubold (1971) considered the trackmaker of *Brachychirotherium* to be an aetosaur, but the proportions of the pes track also are notably similar to those of the plantigrade rear foot of the crocodylotarsan *Postosuchus* (Chatterjee 1985).

The fourth and fifth (part and counterpart) slabs (USNM 412535) contain impressions of digits III and IV, and a probable faint impression of digit II, of a small bipedal animal (Fig. 7). The proportions and relative straightness of the toes suggest that the trackmaker was a small (around 0.5 m long) functionally tridactyl archosaur. Although imperfectly preserved, this track is fully comparable to the ichnotaxon *Plesiornis pilulatus* E. Hitchcock (Fig. 8), originally described from the Portland Formation (Lower Jurassic) of Massachusetts (Lull 1953). The Culpeper basin occurrence represents a significant downward extension of its known range.

Ellenberger (1972) and Lockley et al. (1992) have described very bird-like tracks (*Trisauropodiscus*) from rocks of Early Jurassic age. Lockley et al. (1992) also noted that several Early Jurassic Newark taxa show strongly bird-like characteristics (*Sillimanius tetradactylus, Argoides macrodactylus, A.*

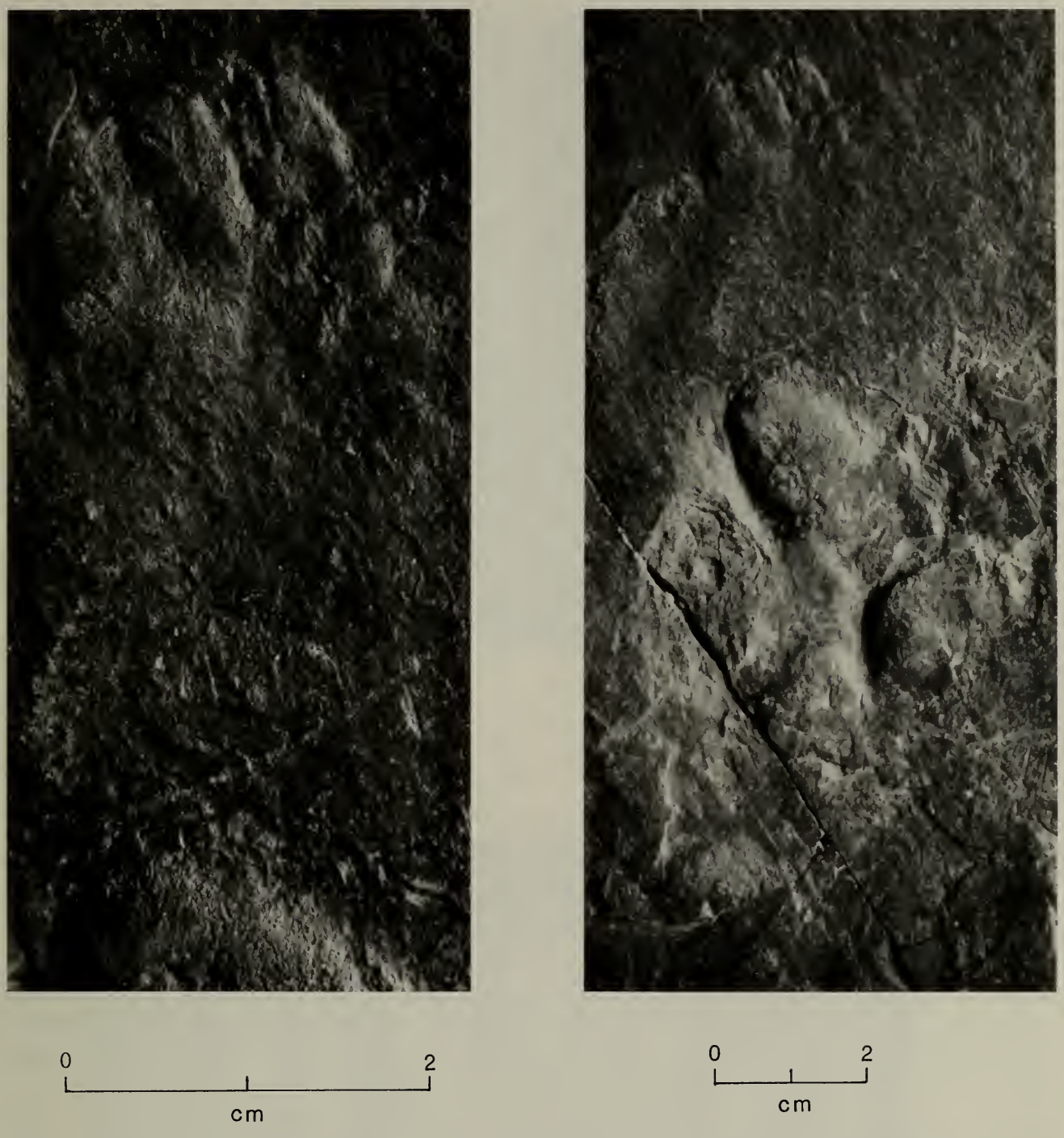

Fig. 5. (right) Counterpart left manus and pes set (USNM 412534) referable to *Brachychirotherium parvum*, (left) closer photograph of manus print of same specimen of *Brachychirotherium*.

minimus, Triaenopus lulli, and *T. emmonsii*). Similarly, *Plesiornis pilulatus* (as its generic name suggests) is markedly bird-like. The prints are small, evidence of footpads is often lacking (Lull 1953), the toes are long and narrow, and there appears to be at least some indication of a rearwardly rotated hallux in the type. The only characteristic that debars *Plesiornis* from the avian ichnofamily Trisauropodiscidae is its II–IV digit divarication, which is about 70°. Trisauropodiscidae should have a II–IV digit divarication of 90° or greater.

But even though the II–IV digit divarication of *Plesiornis* is less than that of typical birds, it is greater than that of typical Triassic dinosaurs (30° to 50°). Considering that this print comes from rocks of early Norian age, and that ancestral birds ultimately should converge back toward a more

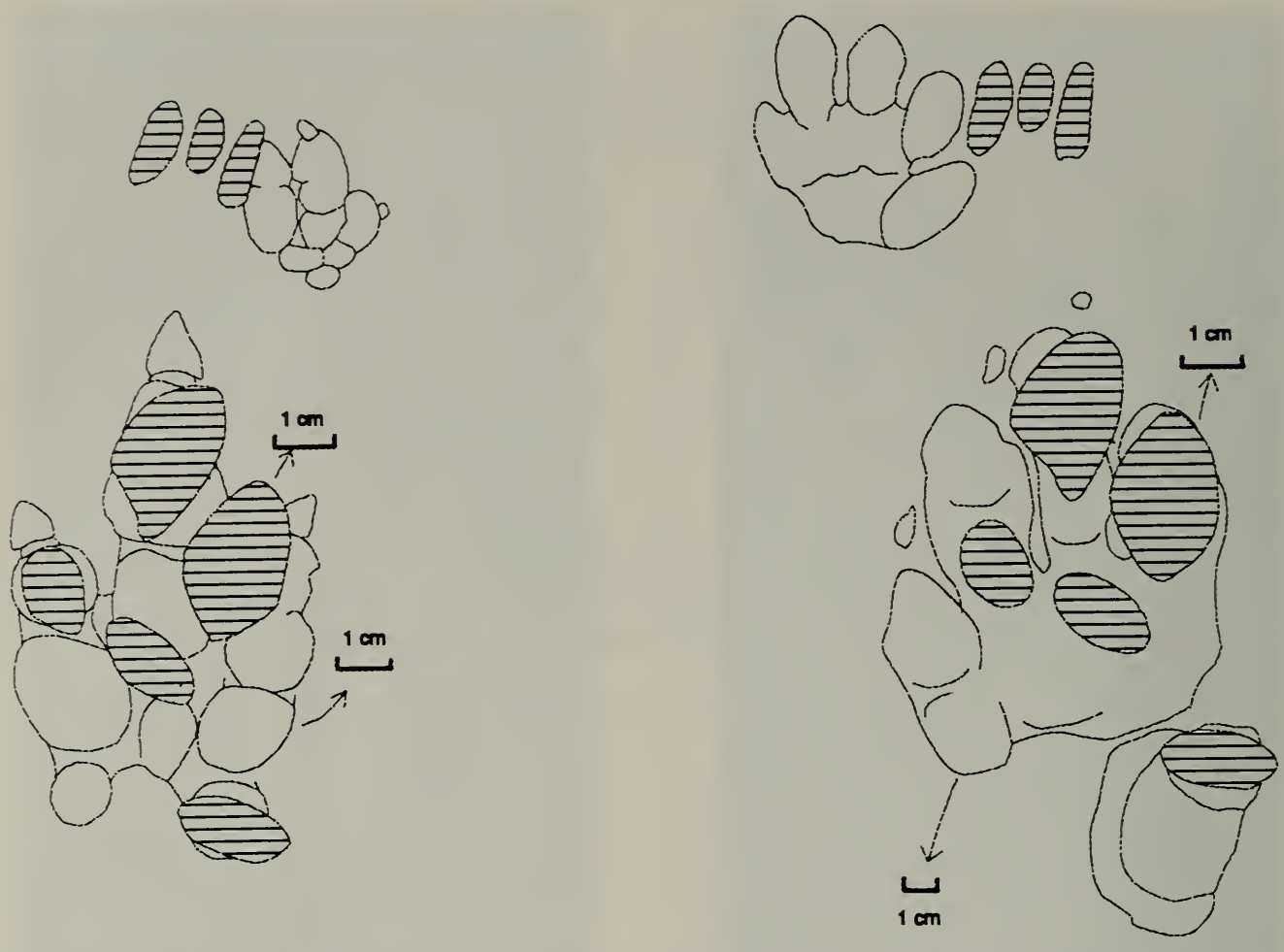

Fig. 6. Outline drawings of right pes of *Grallator tuberosus* (="*Atreipus mildfordensis*") (after Olsen & Baird 1986) (left) and *Brachychirotherium parvum* (after Baird 1957) (right) with mirror-reversed outline of print shown in Fig. 4 (shaded) superimposed upon them.

dinosaur-like foot pattern as the two lineages approach a common ancestor, it should not be surprising if footprints of early Norian bird-like animals were rather intermediate in appearance between those of typical birds and typical dinosaurs. As osteological remains of a Late Triassic (early Norian) bird (*Protoavis*) recently have been described from Texas by Chatterjee (1991), this raises the possibility that our small track, of nearly identical age and estimated size, was made by a protoavid. Therefore we are inclined to view *Plesiornis pilulatus* as a primitive bird or near-bird, possibly a protoavid.

Fish Material

Fish remains are locally abundant in the Jurassic column of the Culpeper basin (Schaeffer & McDonald 1978), but they are rare in the Triassic column (Gore 1986). Therefore, it is noteworthy that a scale impression of a large coelacanth (USNM 421762) (Fig. 9) was found in the lower part of the Balls Bluff Siltstone near the locality at Dulles Airport that yielded parasuchian bones and armor (Weems 1979). Other reports of coelacanths in the Newark Supergroup have been from lacustrine beds, but the beds in the Dulles Airport area appear to be fluvial, rather than lacustrine, in origin. This suggests that *Diplurus* probably inhabited river systems as well as lakes during the Late Triassic.

Two coelacanth taxa are known from the Norian and Jurassic portions of the Newark Supergroup. *Osteopleurus newarki* (Bryant) occurs in the Triassic part of the Newark basin and the Danville basin (Olsen 1988).

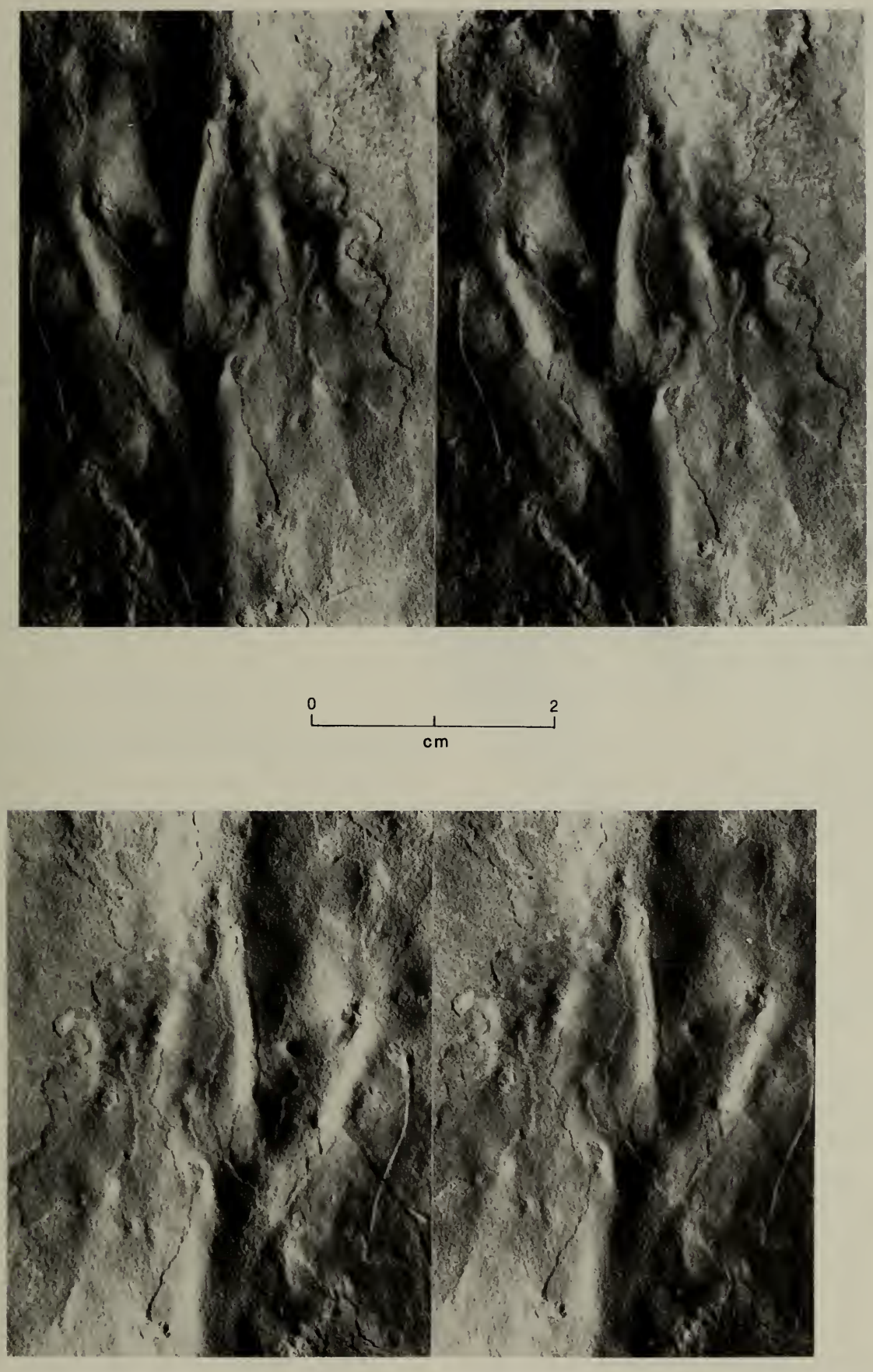

Fig. 7. Stereophotographs of part (top) and counterpart (bottom) slabs containing left footprint of *Plesiornis pilulatus* (USNM 412535).

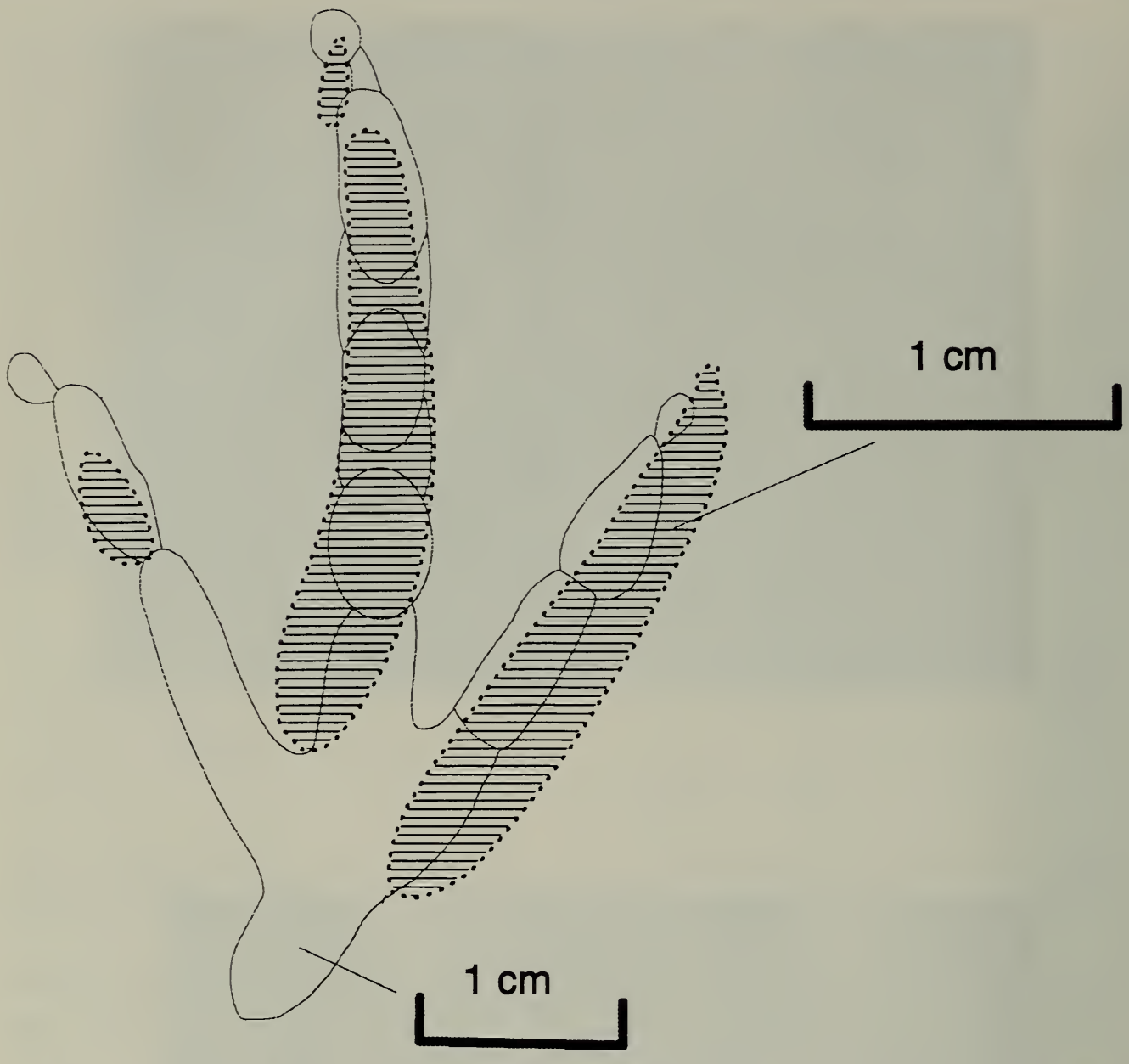

Fig. 8. Outline drawing of a type footprint of *Plesiornis pilulatus* (after Lull 1953) with outline of Culpeper basin print (mirror-reversed) superimposed upon it.

Diplurus longicaudatus Newberry is known from the Jurassic part of the Hartford and Culpeper basins and from the Triassic and Jurassic parts of the Newark basin (Schaeffer 1952, Lull 1953, Schaeffer & McDonald 1978). Because specimens of *Osteopleurus newarki* are not known to exceed 20 cm in total length (Schaeffer 1952:54), their scales usually are much smaller than those of *Diplurus*. Also, *Osteopleurus* flank scales bear only a few widely spaced longitudinal ridges (around 8–10), while scales of *Diplurus* bear numerous (20–30) closely spaced longitudinal ridges. Our specimen has about 25 closely spaced longitudinal ridges and a size that is comparable only with scales from larger specimens of *D. longicaudatus*. Therefore, it probably pertains to *Diplurus*. A species assignment is inadvisable because the few fragmentary specimens of *Diplurus* known from the Triassic portion of the Newark Supergroup are too incomplete to be sure if they pertain to *D. longicaudatus* or to an unnamed antecedent species of this genus.

The occurrence of a large coelacanth in fluvial Triassic sediments raises the interesting possibility that this scale could per-

tain to *Chinlea* (Schaeffer 1967). *Chinlea* is known so far only from the Chinle and Dockum formations of the American Southwest (Murry 1986), but the fact that it occurs in beds that are comparable in age and depositional setting to those of the lower Balls Bluff is suspicious. *Chinlea* reached a size comparable to that of *Diplurus* (Schaeffer 1967), and it also had numerous, closely spaced, longitudinal striations on its scales (up to 40). Therefore, no obvious size or ornamentation characteristics preclude the possibility that this genus could be represented by this specimen. But because *Chinlea* has never been reported from the eastern United States, and because the striation count on our specimen is more typical of *Diplurus* than of *Chinlea, Diplurus* is the more logical assignment based on current knowledge.

Fig. 9. Impression of a large coelacanth fish scale, probably *Diplurus* (USNM 421762), showing rounded outline and numerous, closely spaced longitudinal striations. Length about 2 cm.

Discussion

On the basis of palynological correlations (Cornet 1977, Litwin et al. 1991) the Manassas Sandstone and Balls Bluff Siltstone are correlated with the Upper Triassic Passaic Formation of the Newark basin. The Passaic is known to contain at least 20 kinds of vertebrates. Fish remains include *Semionotus* sp., *Synorichthys* sp., *Diplurus* sp., and *Osteopleurus* sp. (Schaeffer 1952, Olsen 1988). Osteological remains of reptiles include a parasuchian (*Rutiodon*?), the procolophonid *Hypsognathus fenneri,* and the aetosaur *Stegomus arcuatus* (Huene 1913, Colbert 1960, Baird 1986). Reptilian footprint taxa include *Apatopus lineatus, Grallator parallelus, G. tuberosus, Brachychirotherium eyermani, B. parvum, Chirotherium lulli, Coelurosaurichnus* sp., *Gregaripus bairdi* (="*Genus Incertum*" of Baird 1957), *Gwyneddichnium majore* (probably made by *Gwyneddosaurus*), *G. minor, Procolophonichnium* sp. (probably made by *Hypsognathus*), *Rhynchosauroides brunswickii* and *R. hyperbates* (Baird 1957, 1986; Olsen & Baird 1986; Olsen 1988).

The Manassas Sandstone and Balls Bluff Siltstone together have yielded 13 kinds of vertebrates. Osteological remains from the Balls Bluff Siltstone represent a parasuchian (*Rutiodon*?), *Diplurus* sp., and *Semionotus* sp. (Weems 1979, Olsen 1988). The Balls Bluff also has yielded seven kinds of reptile footprints: *Grallator tuberosus, Grallator sillimani, Gregaripus bairdi, Agrestipus hottoni, Kayentapus minor,* and *Eubrontes* sp. from the Culpeper Crushed Stone quarry (Weems 1987, 1992), and *Gwyneddichnium majore* from Manassas National Battlefield Park (considered by Olsen as *Rhynchosauroides* in Gore 1988). The Manassas Sandstone has yielded footprints of *Brachychirotherium parvum, Chirotherium lulli,* and *Plesiornis pilulatus.*

Collectively the Passaic, Manassas, and Balls Bluff contain 25 known kinds of vertebrates. Of these, 8 occur in both basins (*Semionotus, Diplurus, Rutiodon*?, *Gwyneddichnium majore, Grallator tuberosus, Gregaripus, Brachychirotherium,* and *Chi-*

rotherium). Because neither the Passaic nor the Manassas/Balls Bluff are richly fossiliferous, the high number of apparently endemic forms is not surprising. It is more significant that the Passaic and Manassas/Balls Bluff have many more forms in common with each other than either does with any other interval within the Newark Supergroup. Thus the correlation of these intervals in the Culpeper and Newark basins is supported by the known vertebrate remains.

Three vertebrate taxa (*Semionotus, Diplurus,* and *Grallator*), reported from both Triassic and Jurassic strata in the Culpeper basin, are known elsewhere in the Newark Supergroup from both Triassic and Jurassic strata. Other ichnotaxa reported from Lower Jurassic strata of the Culpeper basin, *Eubrontes giganteus* and *Eubrontes minusculus* from the Aldie locality in the Turkey Run Formation (Pannel 1985, taxonomically updated per Weems 1992), and a *Batrachopus* sp. found by Tucker F. Hentz from the same area, are known elsewhere in the Newark Supergroup only from beds dated as Early Jurassic (Olsen 1988). Similarly, other fish from the Early Jurassic portion of the Culpeper basin (*Redfieldius* and *Ptycholepis*) are known elsewhere in the Newark Supergroup only from beds of Early Jurassic age (Schaeffer & McDonald 1978). Thus a common pattern of faunal succession can be documented by vertebrate fossils in both the Newark basin and the Culpeper basin. This pattern is in accord with the palynofloral correlations made between the basins by Cornet (1977), and thus supports those correlations.

Acknowledgments

The authors wish to thank D. Baird, P. Dodson, A. J. Froelich, N. Hotton III, J. P. Smoot, and two anonymous reviewers for their comments, insights and suggestions. We also thank D. Bryan Stone III for taking the stereophotos of *Plesiornis*.

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(REW) Mail Stop 928, U.S. Geological Survey, Reston, Virginia 22092, U.S.A.; (PGK) 9713 Damascus Drive, Manassas, Virginia 22110, U.S.A.